PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: PAUL E. WILLIAMS and CARL OTTO HORST

982,898

982,898

Date of Application and filing Complete Specification Aug. 8, 1961.

No. 28639/61.

Complete Specification Published Feb. 10, 1965.

GT. BRIT. 45c
DIV.

Index at acceptance: —B7 W(3C4, 23, 31A, 31B); B7 G(21F1, 25F, 27A1, 27A3, 28G1A, 28H, 28K1)

Int. Cl.: —B 64 c//B 64 d

COMPLETE SPECIFICATION

Airplane with Adjustable Wings and Tail

We, ADVANCED AIRCRAFT DEVELOPMENT CORPORATION, a Corporation organized and existing under the Laws of the State of Virginia, United States of America, of 1327, Larchmont Drive, Falls Church, Virginia, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to heavier than air airplanes and more particularly to an airplane having an improved arrangement and manner of controlling its wing and tail.

An object of the invention is to provide an airplane wherein the efficiency of operation is considerably improved over known successful airplanes, by virtue of increasing the aerodynamic efficiency of the airplane. Certain advances in the design of our airplane have made it possible to increase the air plane efficiency to the extent of having a very large ratio of weight to horsepower, and maximum speed to minimum speed. Furthermore, the airplane has eliminated the ailerons and rudders ordinarily found in airplanes and provides a new system for airplane control.

The nature and substance of the invention may be considered as contained principally in a tail which is integrated with the fuselage and wing in a particular manner to alter a two dimensional flow condition generated by the airplane and wing configuration, i.e. extend or deflect it to achieve all of the necessary and desirable attitudes and directional control for the aircraft with minimal aerodynamic drag.

In accordance with the foregoing it is an object of the invention to provide an aerodynamically efficient airplane wherein the wings, fuselage and tail are integrated as a unit to improve aerodynamic efficiency and to provide maneuvering and attitude controls by altering the lift coefficients and changing the centre of pressure as opposed to creating movements by aerodynamic functions such as deflecting a rudder in the airstream or deflecting ailerons or rudder and aileron equivalents.

According to the invention there is provided an airplane having a longitudinal airframe axis, wings extending transversely of the axis, a tail having leading edges extending rearwardly and laterally of the axis and so spaced rearwardly of the trailing edges of the wings as to function as an aerodynamic continuation of the wings, and means for adjustably positioning the tail relative to the wings whereby the effective airfoil contour of the individual wings may be selectively asymmetrically extended in different directions by the tail to enhance lift and effect attitude control of the airplane. When referring herein to the tail being so spaced rearwardly of the trailing edges of the wings as to function as an aerodynamic continuation of the wings we are defining the tail as being so positioned as to lie in the streamline flow of air over and from the wing, air that flows above and below the tail having previously flowed respectively above and below the wing.

Our wings, in its preferred form, has areas which are arbitrarily designated as inboard airfoil panels and outboard panel sections respectively, although structurally each semi-span containing a single inboard and a single outboard panel, is made by usual fabrication techniques as a single unit and the panels may not be visibly distinguishable. The inboard panels and the major portion of the outboard panels fly in a two dimensional flow with effectively near infinite aspect ratio;

[Price 4s. 6d.]

the inboard panels and major portions of the outboard panels are the principal lift producing parts of the wing. The existence of the outboard panels induces flow in such directions as to enable the entire inboard panels and much of the outboard panels to fly as in infinite aspect ratio. To the extent that the outboard panels enable the inboard panels and some areas of the outboard panels to operate under essentially ideal conditions, i.e. two dimensional flow, the outboard panels contribute greatly to the lift of the entire airplane.

The outboard panels are preferably swept back while the inboard panels are swept forward. An apex may be at the juncture of the inboard and outboard panels. This juncture may occur at 33—44% of span as measured from the root, depending on various aerodynamic factors. The spanwise component of flow is reduced as compared to standard aircraft. Two things are directly achieved by this condition. First, a flow barrier is established at the juncture of the outboard panels with the inboard panels and this flow barrier operates precisely as infinitely long and high plates which are physically secured to the tips of a wing such as is usually considered to produce ideal two-dimensional flow. Such plates are obviously structures to be considered only in theoretical aerodynamics and cannot be used for practical flight. However, the benefits of such plates are obtained by our outboard panels preventing a spanwise outboard and upward flow over the lower surface of the wing in flight. In a standard airplane the flow starts on to the wing chordwise, enters an area of maximum compression and turns abruptly (inboard or outboard depending on whether it is on the top or bottom) spanwise. Our wing prevents the build up of the maximum pressure on its lower surface at the tip thereby allowing the air to continue without the abrupt change in direction. The second thing achieved by the outboard panels is to induce chordwise inboard and upward flow on the bottom surface and at the same time accelerating that flow so that the flow velocity over the bottom surface is greater than the forward flight velocity of the wing.

Although there have been prior proposals to obtain flight control and attitude changes in numerous ways, the majority of these proposals rely on the production of moments by adjusting ailerons, aileron equivalents and a rudder or rudder equivalents properly located with reference to the longitudinal axis of the airplane and the centre of gravity of the airplane to obtain sufficiently high moments. This airplane has a single tail made of a flat panel or an essentially flat panel that has a dihedral along a centre line, properly located with reference to the wing semi-spans and the fuselage. The tail has a universal joint movement, being connected to the fuselage by an articulated structure. The various positions of the tail to achieve airplane control and attitude changes are listed in a subsequent schedule herein. However, the tail is not only integrated with the fuselage and wing to achieve flight control, but it also serves to extend the airfoil contour and thus the two dimensional flow of the inboard panels of the semi-spans and produce a considerable amount of control of the air flowing off the trailing edge of the inboard wing panels. For each aircraft configuration, then, the location of the tail is reasonably critical. If it is too close to the wing semi-span inboard panels it will not function to extend the two dimensional flow to the greatest extent. If it is located too far rearwardly of the inboard panels of the semi-span there will not be the necessary continuity and straightening of flow required to extend the two dimensional streamline flow of the inboard panels. The same applies to the vertical positioning of the tail. Properly located, the tail then becomes a combination control element for aircraft maneuvering and an air flow control for the two dimensional flow over surface of the inboard panels of the wing semi-spans.

The physical existence of the tail of our airplane in a location described with reference to the two-dimensional flow inboard panels of the wing semi-spans, controls the air flow leaving the trailing edge of the wing inboard panels and without the assistance of any other mechanical device such as slots or ducts.

The components of flow across the semi-span, which are induced by the outboard panels and in a selected direction overcomes a problem existing in conventional wings. Wing tip vortices or other turbulance because of selected flow direction, do not exist in our airplane. This source of drag is thereby eliminated, and all aerodynamic drag across the inboard panels (which may be 33 to 44% of the span) is effectively cancelled. The leading edge of the outboard panel separates the flow in such a manner that the flow will be streamline. There will be a pressure reduction at the trailing edge of the underside of the outboard panel. This pressure reduction will equalize the pressure reduction at the trailing edge on the upper surface so that the usual upward flow of air at the wing tip is prevented, this being the reason that tip turbulance does not exist. The velocity increasing profile of the undersurfaces of the outboard panels, e.g. a venturi shape induces flow velocity near the leading edge so that the flow at that point has a higher velocity than the forward speed of the wing.

An important preferred feature of this invention is in the use of the modified delta

shaped tail. When combined with wing semi-spans as described above, the tail is capable of establishing the angle of descent or the glide angle while the horizontal reference level of the airplane is approximately horizontal at any angle of descent. With the wing shifted forward and the tail pivotally adjusted to a down position the wing generates maximum lift and maximum drag. The airplane can remain in a nose up attitude while descending with the wing and tail in this position. The airplane can and does glide with the nose up requiring a very short flight path to land.

The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a side view of an airplane embodying the invention in which the tail is shown in the take-off and landing positions in solid lines, in an intermediate cruising flight position in dashed lines, and in a raised position for descending or gliding also in broken lines.

Figure 2 is a top view of the airplane of Figure 1 showing the wing in solid lines in position for cruising flight, in broken lines in a forward position for climbing and maximum lift, and in dashed lines in a rear position for high speed flight, the tail being shown in solid lines for straight and level flight and in the broken and dashed line positions for left and right turning.

Figure 3 is a rear elevational view of the airplane showing the tail arranged for level flight, and also showing in broken lines the tail rolled for banking the airplane.

Figure 4 is a fragmentary perspective view of the airplane with parts shown in section, illustrating principally one control mechanism configuration for adjusting the wing semi-spans and tail to the various positions.

Figure 5 is a top view of a part of the control mechanism for the wing and tail.

Figure 6 is a side view of the mechanism in Figure 5.

Figure 7 is an enlarged sectional view taken on the line 7—7 of Figure 4.

Figure 8 is a diagrammatic rear view of the airplane showing the tail level and the air flow lengthwise of the airplane moving up from the front of the airplane and spilling down off the tail.

Figure 9 is a diagrammatic rear view of the airplane showing the tail in a rolled position and the flow which is continuous from the leading to trailing edge of the wing only on one-semi-span and the flow continuous from the wing leading edge over the trailing edge of the tail for the other semi-span thereby altering the lift coefficient of one semi-span to roll the airplane while in flight.

Figure 10 is an enlarged diagrammatic sectional view showing the profile at 11—11 of Figure 2.

The first part of the following description is devoted principally to a description of the mechanical details of the aircraft structure. Airplane 1 has an ordinary landing gear 2 preferably connected to fuselage 3. Propeller 4 is at the front of the fuselage and is driven by a conventional engine (not shown). Wing 5 has two semi-spans 6 and 7 projecting laterally from the fuselage, and tail 8 is located downstream of the wing semi-spans by being attached to an articulated joint structure that is anchored in the fuselage. The semi-span spars (Figure 4) are attached at their root ends to essentially V-shaped trusses 9 and 11 respectively by pivot connections 10 allowing the wing semi-spans to have independent limited flapping motions to enable each semi-span to seek its own dihedral by flapping in wind gusts. Pivot connections 10 are simply horizontal pivot pins passing through aligned apertures in the interdigitated portions of the spars and trusses 9 and 11 with limited pivotal movement of the wing semi-span permitted, the limit established by stops formed by the confronting adjacent parts of the trusses and wing spars.

Trusses 9 and 11 constitute a part of the means for mounting the wing semi-spans so that they are capable of being adjusted fore and aft on the fuselage. Trusses 9 and 11 have apices which are interlocated by hinge butts 13, and king pin 14 extends through the aligned openings of the hinge butts 13. A tail supporting shaft or arm 16 has an eye 15 at its inner end which is engaged with king pin 14 and fitted between hinge butts 13 (Figure 6). Shaft 16 functions as a support for an articulated joint 17 (Figures 5 and 6) by which tail 8 is connected with the airplane. A king pin supporting frame 18 made of ordinary truss construction is secured to the fuselage structural framing and retains the king pin 14 in an upright position. Bearing bracket 19 is attached to structure 18 and furnishes partial support for shaft 16. Yoke 21 is pivotally mounted on a spindle at the end of shaft 16 and has a pair of rocker arms 22 which protrude laterally from the yoke. The pivotal connection of yoke 21 is obtained by having an opening in one end of the yoke through which the spindle at the extremity of shaft 16 extends, and there is a nut 23 on the spindle holding the yoke assembled on the shaft but enabling the yoke to be oscillated about the longitudinal axis of shaft 16. Tail yoke 24 is provided with a pair of trunnions 25 that are engaged with a block 26 disposed between the top and bottom plates of yoke 21. The trunnions 25 are aligned and establish an axis of pivotal movement for tail yoke 24. The block 26 is capable of oscillat-

ing about the longitudinal axis of the short spindle attached to and located between the upper and lower plates of yoke 21. Accordingly, tail yoke 24 is not only capable of oscillating about the axis of trunnions 25, but it may also oscillate about the longitudinal axis of the block 26 spindle. Further, the entire articulated joint 17 may be rotated about the longitudinal axis of shaft 16 on the shaft spindle. It is now evident that the tail 8 may be articulated in any direction, and the wing semi-spans may be pivoted fore and aft on the fuselage.

Mechanical, pneumatic, electric or hydraulic means or combinations thereof may be used to actuate the wing semi-spans and the tail. For the purposes of illustration a wholly mechanical system is disclosed. The structure in Figure 4 includes a bearing 27 mounted in the fuselage and supporting a telescopic torque shaft 28. A pair of rocker arms 29 is attached to the outer section of the shaft 28 and located behind bearing 27. A pair of cables 30 is attached to rocker arms 29 and to the extremities of arms 22. These are secured to the yoke 21 so that the yoke 21 is capable of being oscillated about the longitudinal axis of shaft 16 in response to rotation of the outer section of telescopic torque shaft 28. The rear end of torque shaft 28 has a pair of rocker arms 33 secured to the inner section or shaft 31, the latter being supported in part by bearing 32 at the front part of the telescopic shaft 28. Cable 34 is attached to one end of rocker arm 33 and is guided by a pulley 35 or the like intermediate its ends, cable 34 having its outer extremity attached to one end of yoke 24. An identical cable 34 is attached to the opposite end of the rocker arm 33, guided over a pulley and secured to the opposite end of yoke 24. It is evident that oscillation of the inner shaft 31 will cause the rocker arm 33 to be oscillated thereby pivotally adjusting tail yoke 24 about the upright pivot axis of the pivot in block 26.

A control lever 38 is mounted at the front of shaft 28 and has link 37 attached to its lower end beneath the lever pivot 39. The purpose of the link 37 is to elevate the tail. Link 37 extends through hollow shaft 28 and is pivotally connected to the lower end of arm 41 that is fixed to the tail yoke 24.

A control assembly 42 is mounted in a place convenient to the pilot, and is operatively connected to control arms 36 and 36' attached to the outer and inner sections of shaft 28 and is also connected to lever 38. Assembly 42 (Figure 7) is mounted in the airplane by a structural support 44, and consists of a handle with which hollow shaft 45 is pivotally connected. An inner shaft 46 is disposed in the hollow shaft 45, and has a pinion 49 secured to its inner end. A vertical spindle 50 is used to attach the handle to the hollow shaft 45, the latter passing through aligned openings in the furcations at the inner end of hollow shaft 45 and through the handle. Gear 51 is fixed to the handle and is enmeshed with pinion 49 so that when the handle is adjusted about its spindle 50 gears 51 and 49 cause the inner shaft 46 to be rotated. Rocker arm 48 is splined or otherwise secured to the inner shaft 46, and rocker arm 47 is splined or otherwise secured to the outer hollow shaft 45. Cables 52 are secured to the ends of rocker arm 47 and to the ends of rocker arms 36' so that when the outer shaft 45 is rotated in either direction, the outer section of shaft 28 is correspondingly rotated. A pair of cables 54 is secured to the ends of rocker arm 48 and to the ends of rocker arm 36 so that when the inner shaft 46 is rotated, rocker arm 48, cables 54 and rocker arm 36 cause a corresponding rotation of the inner section 31 of hollow shaft 28. Lever 38 is attached to the outer end of shaft 46 by a pivot connection 53 so that when the handle assembly 42 is moved fore and aft i.e., slid in its bearing 43, the lever 38 is rocked thereby pushing and pulling link 37 ultimately to cause up and down deflection of tail 8.

The means for articulating the wing semi-spans fore and aft on the fuselage are seen in Figure 5. They are of fairly simple construction, consisting of two screws 55 and 56 that are swivelly attached at their outer ends to the truss supports 9 and 11 by nuts 58 which are pivoted to trusses 9 and 11. The inner ends of the screws are located in gear box 57 containing bevel gears at the ends of each of the screws 55 and 56 and a drive gear to which shafting 60 is secured. Crank 63 extends from gear box 64, the latter being secured to a part of the aircraft fuselage structure. Shafting 60 is driven by the gearing in gear box 64 so that screws 55 and 56 are rotated in the swivel nuts 58 in response to rotation of crank 63. Since the screws are threaded in opposite directions, one being a left hand thread and the other a right hand thread, the wings are caused to move fore and aft by the shifting of the truss supports 11 and 9 about kingpin 14 as the screws are rotated simultaneously.

Wing semi-span 6 has two areas considered as inboard panel 80 and outboard panel 81. The semi-span 7 has identical areas considered as inboard panel 82 and outboard panel 83. Panels 80 and 81 are joined at junction line 84 whose front end is at apex 85 and the leading edge of the semi-span 6. A similar junction line 86 is between panels 82 and 83, and the front end of the juncture line is at apex 87 of the semi-span 7. Each panel has a length

of approximately 30 to 50% of the semi-span, and the exact shape of the inboard panels 80 and 82 is quite arbitrary. The outboard panels 81 and 83, though, are of a special shape. Each of these outboard panels has an airfoil section as shown in Fig. 10. The trailing edge 89 (Figure 3) is elevated above the leading edge for approximately 70% of the outboard panel span. Then it drops below the leading edge near the junction line 84 or 85. The line generated by the trailing edge (Figures 3, 8 and 9) is smoothly curved upwardly as it extends toward the tip, then to the highest elevation at a rear portion of the tip and then smoothly curves downward toward the leading edge. The sectional shape of the outboard panel at a station which is approximately 75% of the outboard panel span is shown in Figure 10. The bottom surface 90 of the outboard panel has a flow velocity accelerating profile, for instance the shape of one-half a venturi, and the general appearance of the panel section is that the section is twisted upwardly approaching the trailing edge. The section of the outboard panel (Figure 10) has a negative angle of attack.

Reference is again made to Figure 2 in order to observe the particular location of tail 8. The hinge axes of the tail are located at approximately the 70% chord station of the wing, and the modified delta tail extends to the rear of the wing when viewing the airplane from the top or from the side. This location of the tail has been found to be optimum for an airplane having the following specifications:

Weight - - -	=	1,000—2,500 lbs.
Span - - -	=	20—30 feet
Inner panels area -	=	60—70 feet^2
Outboard panels area -	=	90—110 feet^2
Tail area - - -	=	20—30 feet^2
Horsepower - -	=	15—35 or less

The following schedule discloses flight conditions i.e. aircraft attitude, lateral control, rolling and others, and the manner of achieving them in flying airplane 1.

1. Wing semi-spans forward and tail down for maximum lift and maximum drag.

2. Wings aft and tail level for minimum lift and minimum drag.

3. Wings forward and tail up at some angle to have the fuselage longitudinal reference plane slightly inclined above the horizontal reference and the angle of descent equal to the angle of the tail.

4. Rolling the tail (Figure 9) to roll the airplane. Rolling the tail causes the airfoil of the inboard panels to be assymetrically extended rearwardly so that the flow of the inboard panel on the low side is spilled so that the kinetic flow becomes less at the trailing edge of the inboard panel; and the tail extends or continues the flow over the panel on high side of the tail so that the kinetic flow continues to the tip of the tail, thereby maintaining higher lift on one wing semi-span and reducing lift on the other wing semi-span. Rolling results but there are no torsional forces transmitted from the tail to the airplane to cause the airplane to roll.

5. To yaw the airplane, the tail is yawed and it induces a curvature in the flow as the airplane moves forward. This is in contrast to the conventional rudder which creates a drag in the airstream with the drag being the force operating through a distance to the CG to form a moment arm for yawing the airplane.

The aerodynamic behavior of the airplane has been briefly discussed. Certain factors are to be emphasized. The outboard panels make it possible for inboard panels 80 and 82 to fly with pure laminar, two dimensional flow, giving the wing an infinite aspect ratio effect. Outboard panels 81 and 83 contribute to horizontal stability and stability along the X, Y and Z axes. The stream lines in Figure 10 show laminar flow, and the venturi principle applies.

It is observed from Bernoulli's equation that the induced velocity from the flow accelerating curved wing surface or modified venturi lower surface 90 of outboard panel 81, produces a controlled stream effective in resisting the dynamic pressure as well as forming a barrier at the inner section or juncture of the outboard panels and the inboard panels, for instance along juncture lines 84 and 86, producing a wall or barrier length at the juncture line 84 and 86 thereby producing infinite aspect ratio effect.

The flow over the inboard panels is chordwise because the outboard panels provide infinite aspect ratio due to the existence of the barriers created by the induced flow approximately at lines 84 and 86 by the spanwise and upward induced flow. According to Prandtl, the bound vortex in front of the wing creates a strong upwash increasing in magnitude as the flow approaches the wing. The velocity of the induced downwash at the wing trailing edge is created by the trailing vortices extending upstream and downstream to infinity. The downwash is twice in magnitude of the local upwash. Adding the tail chord with a length ratio of 100% of the chord of the semi-span aft of the trailing edge of the panel, and a width from three-quarters to $1\frac{1}{2}$ chords will produce an added velocity to the two dimensional flow over

the wing and it has the effect of extending the wing semi-span chord and it further influences the flow over the entire center section (inboard panels) of the wing.

Tail 8 is effective as device for controlling air flow from the inboard panels. According to Prandtl in his discussion of viscosity, the leading edge of the airfoil is the stagnation point of flow over the surface of an airfoil whereat the velocity is zero. The pressure develops its greatest value over the surface of the airfoil; the flow continues beyond this point where it has an increased velocity and a drop in pressure. This condition continues up to the point of maximum thickness of the airfoil and a minimum pressure below ambient. The flow then advances into an area of increasing pressure. On conventional airplanes, the increasing pressure area is the point of adverse pressure gradient and the flow converts its kinetic energy to pressure energy in order to continue its directed motion. If there were no mechanical losses, the air would flow with constant energy. However, there is insufficient energy for the air to reach the trailing edge because the friction between particles of air, parasitic drag, etc. will remove the energy in the boundary layer whether the flow is laminar or turbulent.

In accordance with the Kutta Joukowsky circulation theory, basic circulatory flow may be confined with other types of flow and the velocity at any point may be obtained by simple vector addition of the velocity components by means of superposition. (Aerodynamics of the Airplane by Millikan, printed 1941).

The results obtained from using the tail as a means for extending the effective airfoil contour and controlling the flow of air from the inboard wing panels further improves the airplane's performance in the sense that it enhances the two dimensional flow over the inboard panels of the wing. Using tail 8 in airplane 1, lift may be increased up to five times values now obtained by conventional wings of the same size.

When the wings of the aircraft are rotated about their vertical axes so that the tips thereof move towards the rear portion of the aircraft, it will descend in a nosing down attitude because the position of the centre of lift of the wings has been shifted behind the position of the centre of gravity of the airplane. When the wings are pivoted forwardly so as to shift the centre of lift thereof ahead of the centre of gravity of the airplane, the nose of the aircraft rises, thereby resulting in a climbing attitude. To increase the lift and the drag of the aircraft which is desired when taking off and landing, the tail thereof is pivoted downwardly. Since the tail is so spaced rearwardly of the trailing edge of the wing as in effect to extend the airfoil contour and to function as a continuation of the wing, when the tail moves downwardly it in effect increases the camber of the central portion of the wind thereby increasing its lift and drag. However, when the tail is moved downwardly, it causes a pitching force tending to nose the aircraft downwardly, and if it is desired to maintain level flight or to climb when the tail is down, this is accomplished by pivoting the wings forwardly in relation to the centre of gravity so as to compensate for the pitching effects caused by the downward position of the tail. Thus it is obvious that with the tail all the way down and the wings all the way forward, the maximum amount of lift is obtained. When the tail is in the level horizontal position, it produces a minimum drag and at the same time has little affect on the lifting capacity of the wing. Therefore, the tail is maintained in a level or substantially horizontal position when maximum speed is desired, and the rate of climb or descent of the tail in this position is controlled by the position of the wings in relation to the center of gravity of the aircraft. Also, it is desirable to sweep the wings back as much as possible during high speed flight for reducing the drag produced thereby. When the aircraft is approaching the ground or landing, the wings are moved entirely forward and the tail is moved downward so as to raise the nose of the aircraft while at the same time creating a maximum amount of lift and drag for retarding the forward velocity thereof. This results in the aircraft touching the ground with a minimum of speed.

WHAT WE CLAIM IS:—

1. An airplane having a longitudinal airframe axis, wings extending transversely of the axis, a tail having leading edges extending rearwardly and laterally of the axis and so spaced rearwardly of the trailing edges of the wings, as to function as an aerodynamic continuation of the wings, and means for adjustably positioning the tail relative to the wings whereby the effective airfoil contour of the individual wings may be selectively asymmetrically extended in different directions by the tail to enhance lift and effect attitude control of the airplane.

2. An airplane according to claim 1, wherein the tail is mounted upon a universal joint structure supported by the airframe.

3. An airplane according to claim 2, wherein the universal joint structure is carried by an arm mounted on a support for the wings.

4. An airplane according to claim 3, wherein the wings are mounted upon arms pivotally mounted on the support for movement about an axis vertical with respect to the airframe axis.

5. An airplane according to claim 4, wherein the wings are pivotally supported on the

opposite ends of the arms to the pivotal mounting of the arms on the support.

6. An airplane according to any one of claims 2 to 5, wherein the universal joint structure comprises an axis extending generally longitudinally of the airplane and two mutually perpendicular pivot axes whereby the tail may be swung about the three axes in relation to the airframe, a linkage being provided from the tail and universal joint structure to a control assembly whereby operation of the control assembly controls the position of the tail relative to the airframe.

7. An airplane according to claim 6, wherein the universal joint structure permits the tail to pivot about a horizontal axis parallel to the pitch axis of the aircaft for varying the effective camber and lift of the wing and the wings are pivotable about a vertical axis so as to move the centre of lift thereof to compensate for pitching forces caused by up and down pivotal movement of the tail.

8. An airplane according to claim 6 or 7, wherein the tail is pivotable about an axis parallel to the longitudinal airframe axis for creating more lift on one side of the aircraft and causing it to roll.

9. An airplane according to claim 6, 7 or 8, wherein the tail is pivotable about a vertical axis so as to function as a rudder.

10. An airplane according to any preceding claim, wherein the tail has a narrow forward portion and the sides thereof diverging rearwardly to form a generally triangular shape in plan.

11. An airplane according to claim 10 when appendant to claim 2, wherein the narrow portion is connected by the universal joint structure to the airframe between the roots of the wings.

12. An airplane according to any preceding claim, wherein each wing comprises an inboard airfoil section and an outboard section, means being provided for preventing modification of the two dimensional flow about the airfoil means produced by movement in the direction of the airframe axis.

13. An airplane according to claim 12, wherein the means for preventing modification of two dimensional flow comprises the outboard section which is cross-sectionally shaped for superimposition of a circulating flow opposite in circulatory direction to the lift-producing circulatory flow superimposed on the airfoil section in response to movement thereof in the direction of the airframe axis.

14. An airplane according to claim 13, wherein the outboard section has a negative angle of attack.

15. An airplane according to claim 13 or 14, wherein the outboard section is inclined rearwardly with respect to the airfoil section.

16. An airplane constructed and arranged substantially as herein described with reference to and as illustrated in the accompanying drawings.

J. A. KEMP & CO.,
Chartered Patent Agents,
14, South Square, Gray's Inn,
London, W.C.1.

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1965.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

244/46

~~244/46~~

244/46

15

898 SHEETS COMPLETE SPECIFICATION
This drawing is a reproduction of the Original on a reduced scale
Sheet 1

Fig. 4

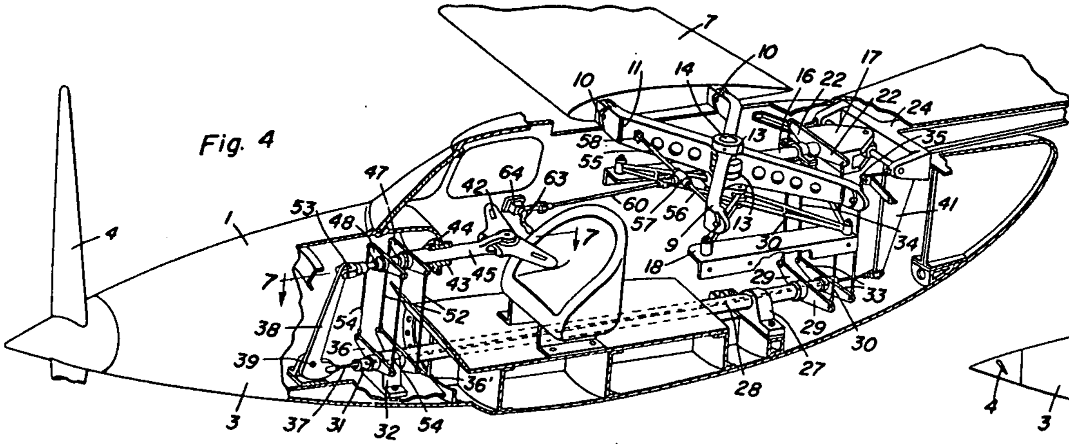


Fig. 2

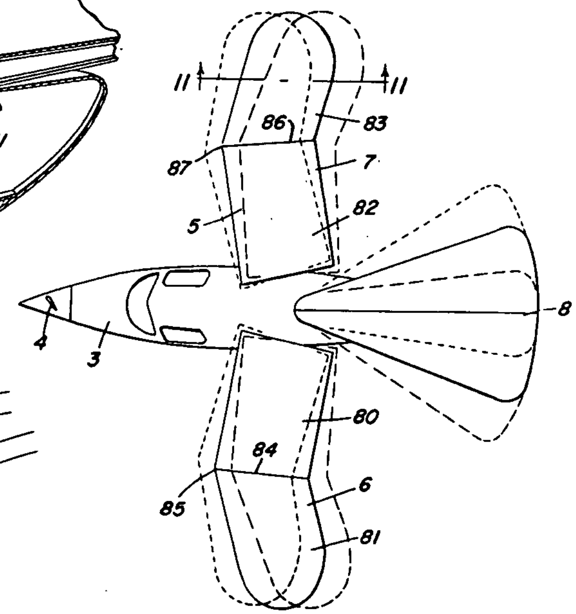


Fig. 10

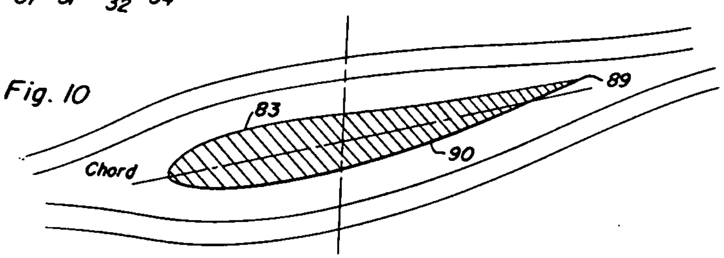


Fig. 1

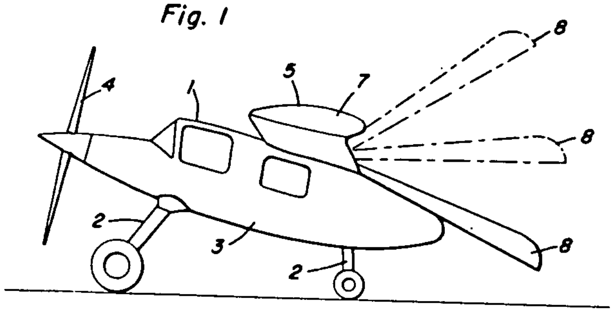


Fig. 9

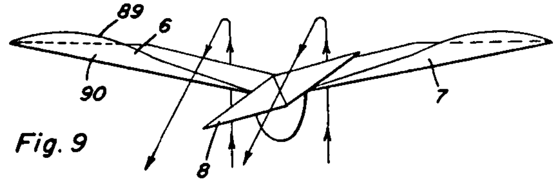
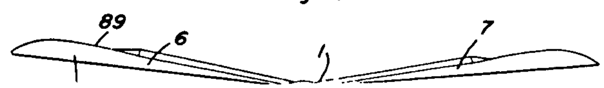


Fig. 3



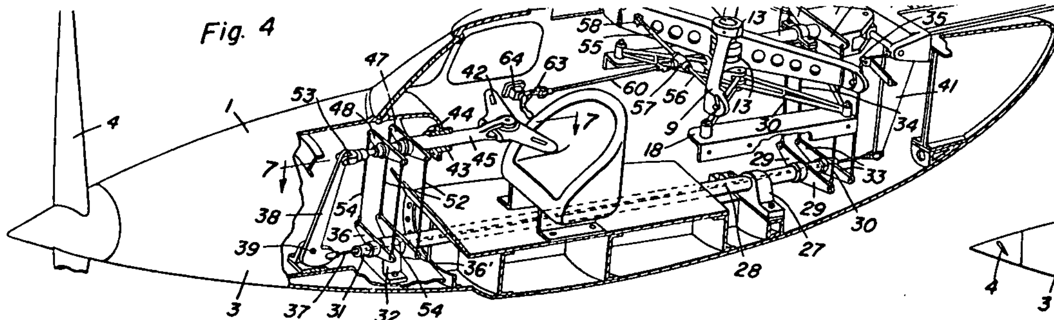
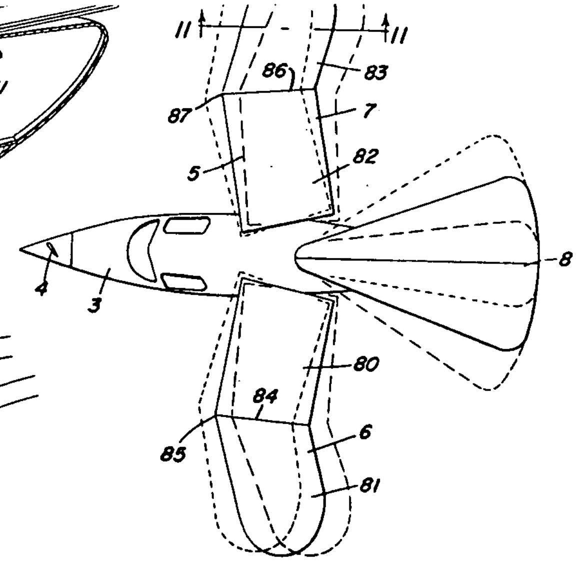


Fig. 4



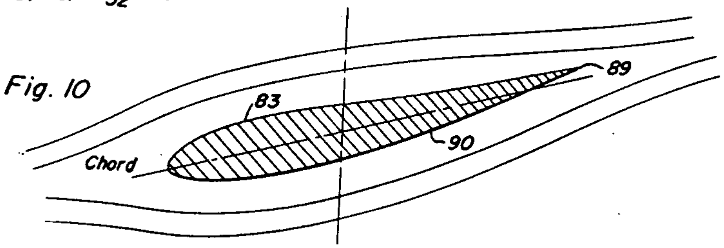
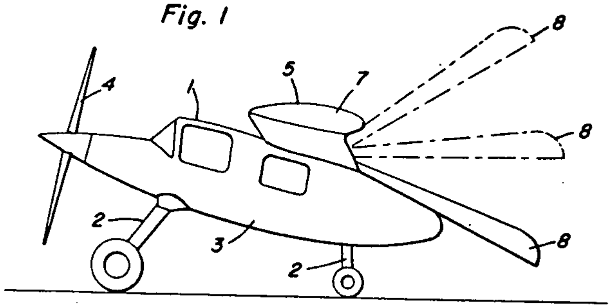


Fig. 10

Fig. 1



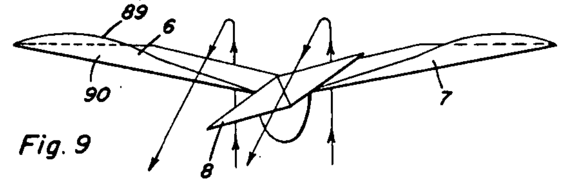
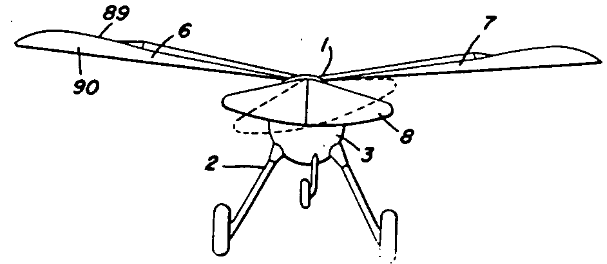


Fig. 9

Fig. 3



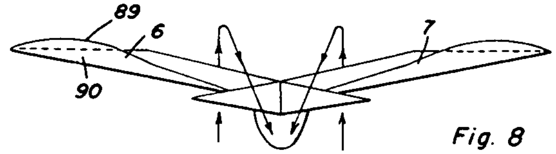


Fig. 8

982898 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

Fig. 5

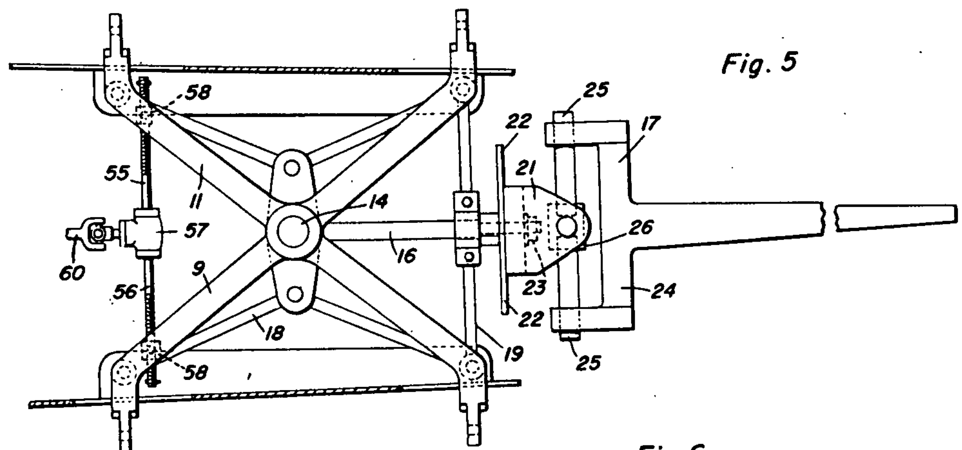


Fig. 6

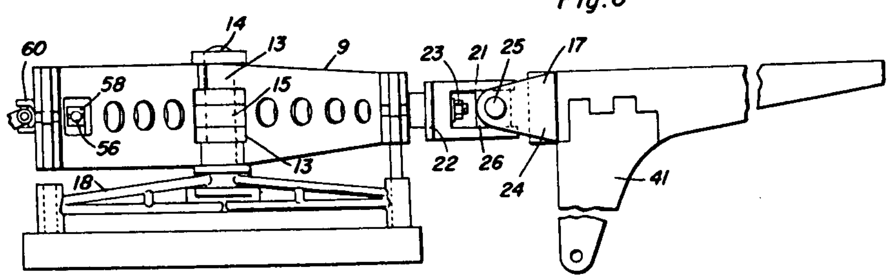
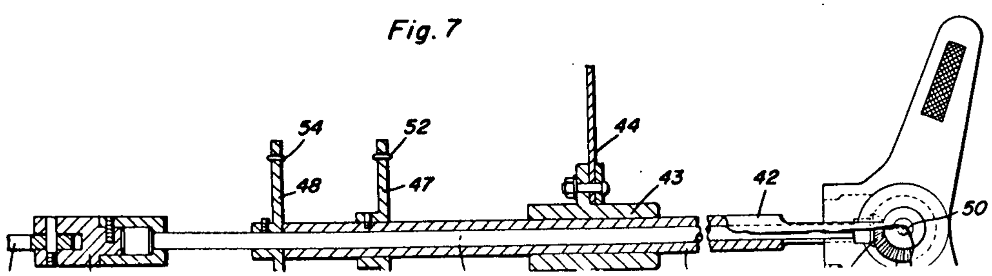


Fig. 7



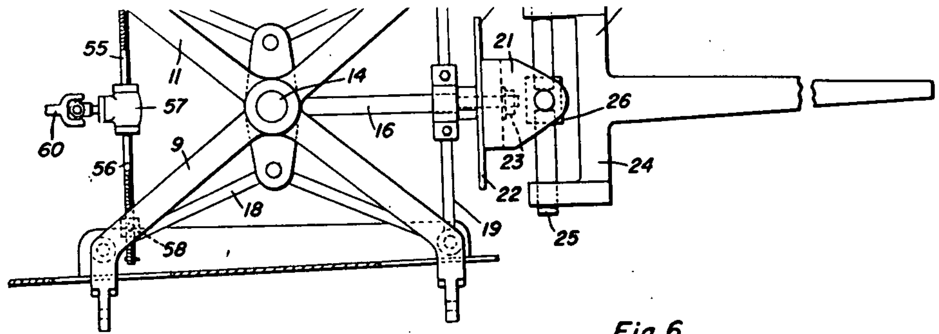

55
11
14
57
60
16
26
21
23
9
56
24
18
22
19
58
25

Fig.6

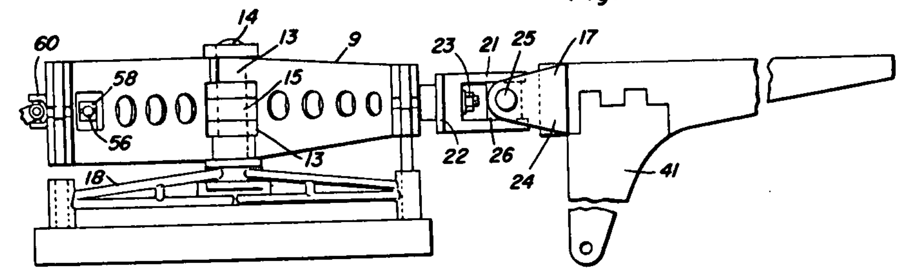
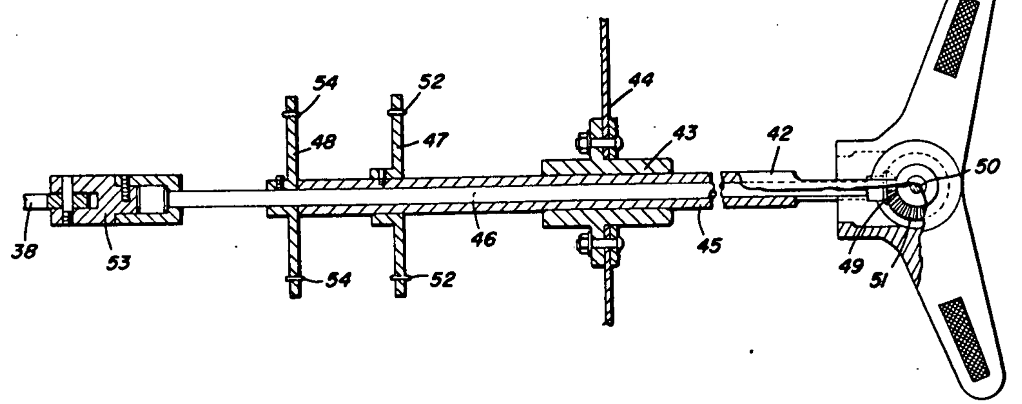

14
13
9
60
58
15
23
21
25
17
56
13
22
26
24
18
41

Fig. 7


54
52
44
48
47
43
42
50
38
53
46
45
49
51
54
52